FLAT PANEL SURFACE ARRAY

Related Applications

This application claims the priority benefit under 35 U.S.C. § 119(e) to United States Provisional Patent Application No. 60/464,672, filed on April 22, 2003, which application is hereby incorporated by reference in its entirety.

Background of the Invention

Field of the Invention

The present invention generally relates to a loudspeaker having a plurality of flat panel speakers or planar magnetic transducers. More particularly, the present invention relates to a surface loudspeaker array using a plurality of full-range flat panel or planar magnetic transducers that are mounted closely together on either a flat or a curved surface to produce a substantially controlled sound dispersion in both the horizontal and vertical planes.

Background of the Invention

Designing audio systems for venues such as stadiums, auditoriums, or theme parks can be difficult. Most companies use traditional speakers arranged in line arrays for such professional applications. The individual speaker elements are typically designed as two- or three-way speaker boxes with direct radiating woofer sections and horn-loaded midrange and tweeter drivers.

Line arrays of speakers are used only infrequently in a straight-line or vertical column configuration, however, because a line array in straight-line configuration has a very narrow vertical sound dispersion. Thus, a line array in straight-line configuration covers a very limited space in the vertical plane. To increase the vertical coverage, the individual speakers in the line arrays are usually curved in the vertical direction, or "vertically splayed," to achieve the desired sound dispersion angle.

The column of speakers is suspended in the air near the area where the sound is desired by various diverse rigging systems. The rigging systems connect the speaker boxes in a compact structure that curves adequately in the vertical plane to provide the desired vertical sound coverage. If the vertical splaying angle between individual speakers is too great, there will be a gap in the sound dispersion, so the vertical splaying angle between line array

speaker boxes is usually no more than 5 degrees. A line array of typical speakers would require a vertically curved column of 16 speaker boxes to achieve 80 degrees of vertical coverage, but such an array is both extremely heavy and very expensive. It is therefore not a practical solution for the vast majority of venues.

To keep costs and weight low while still providing vertical sound coverage, the normal solution is to use shorter line arrays with smaller vertical coverage to cover the middle and rear of the venue, and to add separate fill speakers that are used to cover the front of the venue. Unfortunately, this solution produces distorted sound quality in portions of the venue.

Another difficulty with current line array systems particularly affects travelling productions that carry their own audio equipment, such as touring bands that play to large crowds in large venues. An enormous amount of audio equipment is necessary to fill the typical venues at which those travelling productions play with high quality, high volume sound. Thus, the travelling productions must carry with them trailer loads full of speakers, rigging systems, crossovers, computer and electronics equipment, cabling, and the crews who actually set up and remove the equipment. Those crews must spend hours setting up and testing the equipment before each show, and then additional hours after the show removing and storing the equipment.

Another problem with current line array systems involves the rigging systems used to connect the speaker boxes in a structure that curves adequately in the vertical plane to provide the desired vertical sound coverage. Although traditional rigging systems are able to control the vertical splaying angle between individual speakers or rows of speakers, such systems, particularly for larger arrays, can be extremely complicated, difficult to deploy, heavy, and expensive.

An additional problem is that in situations where wider than nominal horizontal sound coverage is desired, simply adding another line array close to the first array is usually not possible due to large phase problems and destructive interference from arrays closely spaced together in the horizontal plane. To avoid those problems, frequently two arrays must be widely separated, which can be extremely difficult or impossible in many situations because of space restrictions.

Summary of the Invention

Accordingly, a speaker array assembly is desired that can address one or more of these concerns. The speaker array assembly can use a plurality of full-range flat panel or planar magnetic transducers that are mounted closely together on either a flat or a curved surface to produce a substantially controlled sound dispersion in both the horizontal and vertical planes.

One embodiment of the present invention provides a surface loudspeaker array that enables sound dispersion in both the horizontal and vertical planes for very high quality, high volume sound. In one preferred embodiment, the surface array is particularly adapted for professional audio applications, particularly in large venues. The surface array preferably uses flat panel speakers or planar magnetic transducers that are mounted closely together on either a flat or a curved surface.

One aspect of an embodiment of the present invention also provides a method for quickly and easily deploying the surface array. A surface array can be constructed of a plurality of vertically splayable racks, each of which includes a plurality of flat panel speakers or planar magnetic transducers that are horizontally splayed to a pre-set angle. The vertical splay angle between each adjacent pair of vertically splayable racks can be set individually. In typical use, the surface array is lifted into the air near the target audience location. A grid serves as a hanger for the surface array, which is lifted from two or more suspension points on the grid, which is itself attached to the top of the surface array. The grid can be attached to the surface array in either of two positions. In one grid attachment position, the grid provides a suspension point well in front of the center of gravity of the surface array. In other grid attachment position, the grid provides a suspension point well behind the center of gravity of the surface array. Thus, the grid can be attached in either position, depending on the way the surface array is intended to be deployed.

As the surface array is lifted for deployment, the individual vertically splayable racks automatically splay apart to a pre-set vertical splay angle. A tensioning device, such as a strap, can be attached from a point of the grid to a bar at the bottom of the surface array. Tightening the tension device allows each of the vertically splayable racks to splay to approximately the desired, pre-set splay angle. Because both the horizontal and vertical splay angles between the individual flat panel speakers or planar magnetic transducers are pre-set,

the surface array of an arrangement configured in accordance with certain features, aspects and advantages of the present invention is able to control sound dispersion in both vertical and horizontal planes. Using at least one embodiment, it is possible to achieve any overall horizontal or vertical dispersion angle by using an adequate number of flat panel speakers or planar magnetic transducers in a row for horizontal dispersion, and an adequate number of rows for vertical dispersion.

In one embodiment, the vertical splaying angle between the vertically splayable racks of flat panel speakers or planar magnetic transducers can be adjusted up to ten (10) degrees without losing uniform vertical coverage. Thus, with only eight (8) rows of speakers, this embodiment can achieve up to about 80 degrees of substantially uniform vertical coverage.

Embodiments also provide substantial control over the sound dispersion. Thus, the surface array can provide for very rapid sound attenuation at its ends (almost zero degrees of vertical dispersion), and when the surface loudspeaker array is vertically splayed such that the bottom row of flat panel speakers or planar magnetic transducers is facing directly downward, it achieves a very sharp transition, approximately a foot-wide area, between loud and soft sound. When the surface array is hung high in the air in this manner, sound projection from the surface array is loud in front of the surface loudspeaker array and directly beneath the bottom row of the array (the one facing directly downward), but the sound level drops abruptly upon passing behind the array such that one is no longer directly beneath the bottom row of the surface array. Thus, the array forms a "sound curtain," because the area behind the surface array is in effect isolated from the volume produced by the surface array. In at least one embodiment, the surface array produces full-range sound from about 30 Hz to about 20 kHz.

Acoustic blankets can also be placed across portions of the surface array for sound control. Planar magnetic transducers are characteristically dipole, which means that, unlike typical speakers, they radiate the same sound both to the front and to the rear. Thus, in one embodiment of the present invention, acoustic blankets are placed across a portion of the surface array, and they absorb the waves emanating from that portion of the array and significantly reduce or prevent sound from propagating in that direction. If the back face of the surface array is substantially covered, the dispersion pattern of the surface array is

transformed into a cardioid. In a cardioid dispersion pattern, the radiation pattern in front of the speakers is the same as a dipole dispersion pattern, but the radiation pattern behind the speakers is absorbed almost completely. This absorption reduces noise on stage, and therefore helps to resolve acoustic feedback problems, thus providing the sound designer with more control and flexibility in design. In another embodiment of the present invention, portions of the surface array can be suitably enclosed.

A surface array can be constructed using any number of vertically splayable racks of flat panel speakers or planar magnetic transducers. If a sufficient number of vertically splayable racks is used, the surface array can equal or exceed the Sound Pressure Level (SPL) created by current line arrays.

An aspect of an embodiment of the present invention involves a surface loudspeaker array comprising a plurality of vertically-splayable speaker racks, wherein each the vertically-splayable speaker rack comprises a plurality of planar magnetic transducers or flat panel speakers. A first attachment device engages at least one of the plurality of vertically-splayable speaker racks in a forward or reversed position. The first attachment device comprises a plurality of suspension points from which the surface loudspeaker array can be suspended. A second attachment device engages another one of the plurality of vertically-splayable speaker racks. A tensioning device connects the first attachment device and the second attachment device. A sound dampening device is attached to a back side of the surface loudspeaker array. A plurality of hardware secures the plurality of vertically-splayable speaker racks to one another in a serial manner such that when the vertically-splayable speaker racks are connected using the hardware, the vertically-splayable speaker racks are splayed apart to a pre-set angle when the surface loudspeaker array is in an elevated state.

Another aspect of an embodiment of the present invention involves a surface loudspeaker array comprising a plurality of vertically-splayable speaker racks that are connected together vertically in a serial manner. Each of said vertically-splayable speaker racks includes a plurality of planar magnetic transducers or flat panel speakers.

Yet another aspect of an embodiment of the present invention involves a surface loudspeaker array kit. The kit comprises: a plurality of vertically-splayable speaker racks,

wherein each said vertically-splayable speaker rack comprises a plurality of planar magnetic transducers or flat panel speakers; a plurality of hardware, said hardware adapted to attach said vertically-splayable speaker racks to one another, said hardware comprising means for pre-setting a splaying angle; a first attachment device, said first attachment device adapted to engage at least one of said vertically-splayable speaker racks in a forward or reversed orientation, said first attachment device comprising a plurality of suspension points from which said surface loudspeaker array can be suspended; a second attachment device, said second attachment device adapted to engage at least one of said vertically-splayable speaker racks; and a tensioning device, said tensioning device adapted to engage said first attachment device and said second attachment device.

One other aspect of an embodiment of the present invention involves a method for deploying a surface loudspeaker array comprising a plurality of connected vertically-splayable speaker racks. The method comprises attaching a first attachment device to a surface array made up of a plurality of vertically-splayable speaker racks, lifting said surface array using suspension points on said first attachment device, and attaching a plurality of additional vertically-splayable speaker racks to increase the size of said surface array.

A further aspect of an embodiment of the present invention involves a method of assembling and deploying a surface loudspeaker array comprising a plurality of rows of planar magnetic transducers or flat panel speakers. The method comprises providing a first row of planar magnetic transducers or flat panel speakers, connecting a grid to a first surface of the first row of planar magnetic transducers or flat panel speakers, raising the first row of planar magnetic transducers or flat panel speakers, providing a second row of planar magnetic transducers or flat panel speakers, connecting a first surface of the second row of planar magnetic transducers or flat panel speakers to a second surface of the first row of planar magnetic transducers or flat panel speakers, setting a preselected splay angle between the first row and the second row of planar magnetic transducers or flat panel speakers and raising the first row and the second row of planar magnetic transducers or flat panel speakers such that the first row and the second row of planar magnetic transducers or flat panel speakers can splay to the preselected splay angle.

Brief Description of the Drawings

These and other features, aspects, and advantages of an embodiment of the present invention will now be described with reference to drawings of one or more preferred embodiments, which embodiments are intended to illustrate and not to limit the present invention. The drawings comprise 15 drawings.

FIG. 1A illustrates in a side elevation the front of a surface array composed of multiple vertically-splayable racks suspended in the air with its vertically-splayable racks in a generally non-vertically splayed position.

FIG. 1B illustrates in a side elevation the side of a surface array suspended in the air with its vertically-splayable racks in vertically splayed position, and with a tension strap extending from a grid attached to the top vertically-splayable rack in reversed position to a bar attached to the bottom vertically-splayable rack of the surface array.

FIG. 2 illustrates in an exploded view pieces of a vertically-splayable speaker rack, including a rib, a baffle, and a single representative planar magnetic transducer or flat panel speaker.

FIG. 3A illustrates in a side elevation the end of a rib.

FIG. 3B illustrates in a side elevation the top of a rib and baffle.

FIG. 3C illustrates in a sectional view the back of a rib and baffle with flat panel speakers or planar magnetic transducers installed.

FIG. 3D illustrates in a side elevation the front of a rib and baffle of a vertically-splayable rack.

FIG. 4 illustrates in a side elevation an end piece of a vertically-splayable rack.

FIG. 5A illustrates in an isometric view adjacent end pieces of two vertically-splayable racks, a cam, and attachment hardware.

FIG. 5B illustrates in an isometric view adjacent end pieces of two vertically-splayable racks, a cam, and attachment hardware.

FIG. 6 illustrates in a side elevation two adjacent vertically-splayable racks in vertically-splayed position, a cam, and attachment hardware.

FIG. 7A illustrates in an isometric view a vertically-splayable rack attached to a grid in forward position.

FIG. 7B illustrates in an isometric view a vertically-splayable rack attached to a grid in reversed position.

FIG. 8 illustrates in an isometric view more detail of the bar shown in FIG. 1B.

FIG. 9A illustrates in an isometric view the rear of a surface array with an acoustical blanket attached.

FIG. 9B illustrates in an isometric view one method of attaching an acoustical blanket to the rear of a flat panel surface array.

Detailed Description of the Preferred Embodiment

With reference initially to FIGS. 1A and 1B, a surface loudspeaker array **101** arranged and configured in accordance with certain features, aspects and advantages of the present invention is shown. In one embodiment of the invention, the surface loudspeaker array **101** is advantageously constructed of a plurality of vertically-splayable racks **102** of flat panel speakers or planar magnetic transducers **150** (hereinafter PMT **150**), as shown. In another embodiment not shown, the surface loudspeaker array 101 is advantageously constructed of a plurality of horizontally-splayable racks of flat panel speakers or PMT **150**. In yet another embodiment not shown, the surface loudspeaker array **101** is advantageously constructed of a non-splayable grid of flat panel speakers or PMT **150**. In the illustrated arrangement, four racks **102** define the array **101**. Other numbers of racks **102** also can be used to define an array of a desired configuration. For instance, in one particularly preferred arrangement, eight racks **102** each containing nine PMT **150** are combined into an array **101**. The number of racks **102** that can be connected serially number as many as 32 or more.

The PMT **150** should be closely matched one PMT to another within the array **101** for performance characteristics. Matched, as used herein, means that the overall difference between the absolute high and the absolute low of the specified characteristics one PMT to another within the surface array differ by no more than the designated amount. It is preferable that the frequency responses of the PMT **150** should match one PMT to another within about 5 dB. More preferably, the frequency responses should match one PMT to another to within about 2 dB. Even more preferably, the frequency responses should match one PMT to another within 1 dB. In addition, it is preferable that the resonant frequencies of the PMT **150** match one PMT to another within about 30%. More preferably, the resonant

frequencies should match one PMT to another within about 15%. Even more preferably, the resonant frequencies should match one PMT to another within about 10%. If the frequency responses and resonant frequencies of the PMT **150** are not matched properly, overall sound performance suffers. The PMT **150** themselves could be of shapes other than rectangular, including but not limited to circular, triangular, pentagonal, hexagonal, heptagonal, or octagonal.

With reference to FIG. 1B, the top vertically-splayable rack **102** preferably is attached to a grid **170**, which includes a plurality of suspension points **172**. In one embodiment of the invention, a bar **190** is attached to one of the vertically-splayable racks **102**, and a tension strap **180** is attached to the grid **170** and the bar **190**, as shown in FIG. 1B. Although the bar **190** is shown attached to the bottom vertically-splayable rack **102** in FIG. 1B, in other embodiments, the bar **190** can be attached to other vertically-splayable racks **102**. In one embodiment of the invention, the vertically-splayable racks **102** are connected together using cams **161** and rack connecting hardware **160**. The rack connecting hardware **160** may consist of quick-release pins, bolts, or other suitable hardware.

With reference now to FIG. 2, in one embodiment each vertically-splayable rack **102** is advantageously constructed of a rib **110**, a baffle **125**, and a plurality of PMT **150**. The rib **110** serves as the structural framework for the vertically-splayable rack **102**. The baffle **125** generally insulates the PMT **150** from one another. In one preferred embodiment, the rib **110** and the baffle **125** are advantageously made of aluminum because it is strong yet lightweight, but other materials are acceptable in other embodiments. The PMT **150** produce the desired sound. In one embodiment, nine PMT **150** are mounted to each rack **102**. Other numbers of planar transducers **150** also can be used.

With reference to FIGS. 2 and 3A, each rib **110** advantageously includes a plurality of mounting members **111**. As shown, the mounting members **111** preferably define the general shape of the forward face of the vertically-splayable rack **102**, particularly the horizontal splaying angle (as viewed in a horizontal plane) between individual PMT **150**. With reference to FIG. 2, in one embodiment, the mounting members **111** desirably form segments of an arc-like shape and include a plurality of flattened support positions **112**. In various alternative embodiments, the mounting members **111** could describe an arc encompassing

any number of degrees from the minimum needed for one flattened support position **112** to three-hundred-sixty (a complete circle), the mounting members **111** could include any number of flattened support positions **112**

With reference to FIG 3A, in one embodiment, the rib **110** also advantageously includes a plurality of end members **115**. As illustrated in FIG. 3A, each end member **115** advantageously includes a plurality of rib end holes **116**, a pivot hole **117**, a recessed pivot hole **118**, a locking hole **119**, and a recessed locking hole **120**. In some embodiments, differing numbers of rib end holes **116** at adjusted locations can be implemented.

With reference to FIG. 2, the baffles **125** preferably are secured between the mounting members **111** and the PMT **150**. The baffles **125** generally insulate each individual PMT **150** from vibrations caused by the other PMT **150** in the same vertically-splayable rack **102**. In other words, as sound is generated by any of the sound sources (e.g., PMT **150**), the sound source vibrates and the baffles substantially isolate (e.g., reduce the transference) of vibrational energy from the rack **102**.

With reference to FIGS. 2 and 3A, the mounting members **111** advantageously include a plurality of baffle attachment holes **113**. In one embodiment, the baffle **125** also advantageously includes rib attachment holes **127**. In addition, as shown in FIG. 3D, for instance, PMT mounting hardware **128** can be connected to the baffle **125**. Baffle attachment hardware **114** is inserted through the rib attachment holes **127** and baffle attachment holes **113** to attach the baffle **125** to mounting members **111** of the rib **110**, as illustrated in FIG. 2. Other suitable methods of connecting the baffles **125** to the ribs **110** also can be used.

As explained above, the baffle **125** dampens vibrations from the individual PMT **150**. Thus, in one embodiment illustrated in FIGS. 2 and 3A, the rib **110** and the baffle **125** are separated by baffle insulating strips **135** when attached together. In one embodiment, the baffle insulating strips **135** are advantageously made of foam and of generally rectangular shape, but in other embodiments (not illustrated) the baffle insulating strips **135** may be made of other materials and may be of other shapes so long as the baffle insulator (which need not be a strip) effectively reduces the amount of vibrational energy transmitted to the ribs **110**. Although not illustrated, the rib **110** and the baffle **125**, when attached, preferably are also separated by cushion spacers **136**, which are disposed about the baffle attachment hardware

114 between the rib **110** and the baffle **125**. In a preferred embodiment, the cushion spacers **136** are of a suitable thickness, such that when the rib **110** and the baffle **125** are attached using the baffle attachment hardware **114**, the baffle insulating strips **135** are compressed to a height such that the rib and baffle are slightly spaced apart from each other. In this configuration, the compression helps to ensure contact among the baffle **125**, the baffle insulating strips **135** and the rib **110**.

One aspect of an embodiment of the present invention allows for easy electrical connection of the PMT **150** that make up the surface array **101**. In one embodiment, the rib **110** advantageously includes a plurality of electrical connections **121** (see FIG. 3C) and a plurality of electrical connector tunnels **122** (see FIGS. 2 and 3B through 3D). The electrical connections **121** preferably are placed at the back of the rib **110**, where they are easily accessible from behind the surface array **101**. In the embodiment illustrated, the electrical connector tunnels **122** run from near the electrical connections **121** to a point near the center of the forward face of the vertically-splayable rack **102**. By running electrical wires from the PMT **150** through the electrical connector tunnels **122** to the electrical connections **121**, the illustrated embodiment of the current invention greatly reduces or eliminates tangling of electrical wires from adjacent vertically-splayable racks **102** within the surface array **101**. This construction also advantageously allows for easy electrical connection of racks **102** in the array **101** using jumper cables (not shown).

The baffle **125** can be shaped substantially similar to the ribs **110** to which the baffle **125** is attached. In the illustrated embodiment, the baffle **125** is generally arc-like and includes a plurality of flattened PMT mounting positions **126**, to which the individual PMT **150** will be attached. In the embodiment illustrated in FIGS. 2, 3B, and 3D, the baffle **125** includes one row of flattened PMT mounting positions **126**. The illustrated baffle **125** is also slightly angled between each pair of PMT flattened mounting positions **126**. In other arrangements, the baffle **125** can be angled between each mounting position **126**, between every third mounting position **126** or the like. With reference to FIGS. 2 and 3D, the individual PMT flattened mounting positions **126** preferably are of rectangular shape.

In various alternative embodiments (not shown), the baffle **125** could include more than one row of PMT flattened mounting positions **126**; the slight angle or "horizontal splay"

between each pair of PMT flattened mounting positions **126** could range from about zero (no horizontal splay) to approximately fifteen (15) degrees; the PMT flattened mounting positions **126** could be of shapes other than rectangular, including but not limited to circular, triangular, pentagonal, hexagonal, heptagonal, or octagonal; the baffle **125** could generally describe an arc encompassing any number of degrees from the minimum needed for one flattened PMT mounting position **126** to about 360° (a complete circle); and the baffle **125** could include any number of flattened PMT mounting positions **126**. In one particularly preferred arrangement, the horizontal dispersion angle is approximately 90°. In another preferred arrangement, the horizontal dispersion angle is approximately 60°.

In the illustrated arrangement, the PMT mounting hardware **128** is used to attach the PMT **150** to the baffle **125**. In the embodiment illustrated in FIGS. 2 and 3D, the PMT mounting hardware **128** is disposed in the four corners of each flattened PMT mounting position **126** on the baffle **125**. The PMT mounting hardware **128** may be disposed in different positions around the flattened PMT mounting positions **126**, particularly when the flattened PMT mounting positions **126** are of shapes other than rectangular. Furthermore, the PMT mounting hardware can be connected to the PMT **150** or can be passed through the PMT **150**, the baffle **125** and the rib **110** in some embodiments.

In one embodiment, the PMT **150** are preferably attached to the baffle **125** using the PMT mounting hardware **128**, as illustrated in FIG. 2. In one preferred embodiment, the PMT **150** are separated from the baffle **125** by transducer insulating strips **140**, as illustrated in FIGS. 2 and 3D, and transducer spacers **141**, as illustrated in FIG. 2. In one embodiment illustrated, the transducer insulating strips **140** are advantageously made of foam and of generally rectangular shape, but it will be understood that in other embodiments (not illustrated) the transducer insulating strips **140** may be made of other materials and may be of generally different shapes (and may not be strips in shape). In one preferred embodiment, the transducer spacers **141** are disposed about the PMT mounting hardware **128** between the baffle **125** and the PMT **150**. In a preferred embodiment, the transducer spacers **141** are advantageously of a pre-determined thickness, such that when the baffle **125** and the PMT **150** are attached using the PMT attachment hardware **128**, the transducer insulating strips

140 are compressed to a suitable height. Again, the compression ensures contact between the respective components.

Although it is possible to construct a surface array **101** using only a single vertically-splayable rack **102**, it is generally preferable to construct a surface array **101** from a plurality of vertically-splayable racks **102**. FIGS. 5A and 5B illustrate one embodiment of the invention, in which two adjacent vertically-splayable racks **102** can be advantageously connected in predetermined positions using a plurality of rack connecting hardware **160** and end member **115**, such as those illustrated in FIG. 4. Adjacent vertically-splayable racks **102** advantageously can be connected in either a non-splayable locked position or a splayable unlocked position.

In one embodiment of the invention (similar to that shown in FIG. 6), two adjacent vertically-splayable racks **102a** and **102b**, represented in FIGS. 5A and 5B by end members **115a** and **115b**, can be advantageously connected in a non-splayable locked position using suitable rack connecting hardware **160**. To connect two adjacent vertically-splayable racks **102a** and **102b** in non-splayable locked position, the pivot hole **117** of the end member **115a** of the first vertically-splayable rack **102a** is aligned with the recessed pivot hole **118** of the end member **115b** of the second vertically-splayable rack **102b**. A first piece of rack connecting hardware **160a** is placed through the pivot hole **117** of the first end member **115a** and the recessed pivot hole **118** of the second end member **115b**. The locking hole **119** of the first end member **115a** is also aligned with recessed locking hole **120** of the second end member **115b**, and a second piece of rack connecting hardware **160b** is placed through the locking hole **119** of the first end member **115a** and the recessed locking hole **120** of the second end member **115b**. Thus, when the surface array **101** is lifted, the individual end members **115a** and **115b** are held firmly in place, and the vertically-splayable racks **102** are not able to pivot vertically in relation to one another.

Adjacent vertically-splayable racks **102** advantageously can be connected in splayable unlocked position using a plurality of cams **161** and a plurality of rack connecting hardware **160**. A feature of the embodiment of the invention illustrated in FIGS. 5A and 5B is that, when so attached, the individual vertically-splayable racks **102** automatically splay apart no farther than a pre-set splay angle. This is accomplished using a cam **161** (see

FIG. 5A), which advantageously includes a cam pivot hole **162** and a plurality of splay angle control slots **163**. The splay angle control slots **163** are of differing lengths. Those differing lengths correspond to differing desired angles of vertical splay between the attached vertically splayable racks **102**. The cam **160** is illustrated as wedge-shaped and including five splay angle control slots **163**, but the cam **161** may be of other shapes and have differing numbers of splay angle control slots **163**.

FIGS. 5A and 5B illustrate how two vertically-splayable racks **102a** and **102b** can be connected in splayable unlocked position, using end members **115a** and **115b** to represent vertically-splayable racks **102a** and **102b**. The pivot hole **117** of the first vertically-splayable rack **102a**, represented by end member **115a**, is aligned with the recessed pivot hole **120** of the second vertically-splayable rack **102b**, represented by end member **115b**. A first piece of rack connecting hardware **160a** is placed through the pivot hole **117** of the end member **115a** and through the recessed pivot hole **118** of the second end member **115b**. The locking hole **119** of the first end member **115a** can be aligned with the recessed locking hole **120** of the second end member **115b**, but no piece of rack connecting hardware **160** is placed through the locking hole **119** of the first end member **115a** or through the recessed locking hole **120** of the second end member **115b**. Instead, a cam **161** is placed adjacent to the two end members **115a** and **115b**. A second piece of connecting hardware **160b** is inserted through the cam pivot hole **162** of the cam **161** and also through the rib end hole **116** of the second end member **115b**. The cam **161**, however, is capable of pivotal movement relative to the second piece of connecting hardware 160b. A third piece of rack connecting hardware **160c** is also inserted through one of the splay angle control slots **163** of the cam **161** and through the rib end hole **116** of the first end member **115a**. The desired splay angle control slot **163** that matches the desired vertical splay angle can be aligned with the rib end hole **116** by pivoting the cam **161** prior to inserting the third piece of rack connecting hardware **160c**. For example, in the embodiment of the cam **161** illustrated, the different splay angle control slots **163** correspond to vertical splay angles of about 0°, about 2.5°, about 5°, about 7.5°, and about 10°. In one particularly preferred embodiment comprising eight racks, the overall vertical dispersion resulting from a joining of the eight racks **102** is between approximately 0° and approximately 80°. In another particularly preferred embodiment comprising four

racks, the overall vertical dispersion is between approximately 0° and approximately 40°. Advantageously, the individual rows can be splayed different amounts from the other rows. For example, one row can be splayed about 2.5° and the next row can be splayed about 10°

Once two vertically-splayable racks **102a** and **102b** have been connected together in vertically-splayable position, they will automatically splay apart to the pre-set angle. FIGS. 5A, 5B, and 6 represent two vertically-splayable racks **102a** and **102b** in a vertically splayed position. When the surface array **101** is lifted, the vertically-splayable racks **102a, 102b** pivot about the first piece of rack connecting hardware **160a**, visible in FIGS. 5A and 5B, which is inserted through the pivot hole **117** of the first vertically-splayable rack **102a** and through the recessed pivot hole **118** of the second vertically-splayable rack **102b**. As the two vertically-splayable racks **102a** and **102b** pivot about the first piece of connecting hardware **160a**, the second piece of connecting hardware **160b**, which was inserted through the cam pivot hole **162** of the cam **161** and through the rib end hole **116** of the second vertically-splayable rack **102b**, is automatically moved closer to the third piece of rack connecting hardware **160c**, which was inserted through one of splay angle control slots **163** of the cam **161** and through the rib end hole **116** of the first vertically-splayable rack **102a**. As the second piece of rack connecting hardware **160b** moves closer to the third piece of rack connecting hardware **160c**, the third piece of rack connecting hardware **160c** is automatically moved to one end of one of the splay angle control slots **163**, at which point the third piece of rack connecting hardware **160c** can move no farther. Thus, the two vertically-splayable racks **102a** and **102b** can vertically splay to the desired pre-set vertical splay angle, but no farther apart, similar to the arrangement shown in FIG. 6.

Another feature of the embodiment of the invention illustrated in FIGS. 5A, 5B, and 6 is that the rack connecting hardware **160** can be advantageously composed of a plurality of quick-release locking pins. Thus, a surface array **101** can be constructed quickly of individual vertically-splayable racks **102**, and it also can be taken apart quickly. The pieces of rack connecting hardware **160** could also be bolts, screws or other suitable mechanical components.

With reference to FIGS. 7A and 7B, a grid **170** is shown that assists in the construction and proper deployment of the surface array **101**. The grid **170** advantageously

includes two end pieces **171**, which preferably includes holes that generally align with the pivot hole **117** and the locking hole **119**. The grid **170** may be attached to the top vertically-splayable rack **102** of a surface loudspeaker array **101** using the holes (not viewable) through the end pieces **171**, which are aligned with the pivot holes **117** and locking holes **119** (or, in an alternative embodiment, the recessed pivot holes **118** and recessed locking holes **120**) of the end members **115**, as illustrated in FIGS. 7A and 7B.

In one preferred embodiment of the invention, the grid **170** may be attached to the top vertically-splayable rack **102** of a surface loudspeaker array **101** in a first orientation relative to the rack **102**, as illustrated in FIG. 7A (note the location of the suspension points **173**), or in a second orientation relative to the rack **102**, as illustrated in FIG. 7B. This reversability advantageously provides improved flexibility in mounting configurations. Further, depending upon the orientation, the entire array **101** can be tilted from about 15° forward to about 45° backward. Other ranges of array tilting can be used.

The grid **170** advantageously includes a plurality of suspension points **172**. In one preferred embodiment, the suspension points **172** preferably are disposed in a triangle, as illustrated in FIGS. 7A and 7B, which allows improved stability and facilitates proper positioning when hung. In a preferred embodiment, when the grid **170** is attached to the rack **102** in the first orientation, the grid **170** provides at least one of the plurality of the suspension points **172** in front of the center of gravity of the surface loudspeaker array **101**, and when the grid **170** is attached to the rack **102** in the second orientation, the grid **170** provides at least one of the plurality of the suspension points **172** behind the center of gravity of the surface loudspeaker array **101**. Thus, the orientation of the grid **170** can be selected to provide attachment points in convenient places depending on the desired orientation of the surface array **101** once deployed.

With reference again to FIG. 1B, a tensioning device **180**, such as a strap, rope, cord, banding, tie rod or the like, can be attached from a point on the grid **170** to a bar **190** attached to a lower part of the surface array **101**. The tensioning device **180** should be connected in a manner that secures the array **101** against substantial movement that would result in the splaying angle collapsing. Thus, the grid **170** advantageously includes a plurality of grid rear strap attachment points **173** as shown in FIGS. 7A and 7B. The grid rear strap attachment

points **173** preferably are adapted to engage a tension device **180**. Although in many desired orientations the individual vertically-splayable racks **102** of the surface array **101** will deploy automatically to the full vertical splay angle desired, in other orientations a tension device **180** is attached to the grid **170** to pull the vertically-splayable racks **102** into their fully-deployed position.

With continued reference to FIGS. 7A and 7B, the grid **170** preferably includes at least two grid rear strap attachment points **173**, such that whether the grid **170** is attached to the surface loudspeaker array **101** in either the first orientation or in the second orientation, at least one of the grid rear strap attachment points **173** is disposed toward the rear face of the surface loudspeaker array **101**. The grid **170** also advantageously includes a plurality of bar attachment holes **174**, as also shown in FIGS. 7A and 7B.

With reference now to FIG. 8, the bar **190**, which was discussed above, advantageously includes at least one bar rear strap attachment point **191** that is adapted to engage the tension device **180**. Thus, when the grid **170** is attached to the top of the surface array **101**, the bar **190** can be attached either to the bottom or to another part of the surface array **101**, and the tension device can then be attached between them to force the vertically-splayable racks **102** to deploy substantially as desired.

It is advantageous that the bar **190** be adapted to attach to the grid **170** or to any of the end members **115** of the vertically-splayable racks **102** using a plurality of bar connecting hardware **195**, not illustrated. A plurality of bar connecting hardware **195** is inserted through a plurality of bar end holes **194** in the opposing ends **192** and **193** of the bar **190** and also through a plurality of the rib end holes **116** of the end member **115**. The bar **190** is advantageously designed such that when the bar **190** is attached to the end member **115** of the vertically-splayable rack **102**, the bar rear strap attachment point **191** is easily accessible.

The tension device **180** illustrated in FIG. 1B may in one embodiment include a first end portion **181** and a second end portion **182**. The first and second end portions **181** and **182** of the tension device **180** can be designed to be attachable to the bar rear strap attachment point **191** and the grid rear strap attachment points **173**. It is preferable that each of the first and second end portions **181** and **182** of the tension device **180** be designed to be attachable either to the bar rear strap attachment point **191** or to the grid rear strap attachment

point **173**. In another embodiment, the tension device **180** could be designed such that the first end portion **181** would attach only to one of either the bar rear strap attachment point **191** or the grid rear strap attachment point **173**, and second end portion **182** could be similarly designed.

The tension device **180** may be attached to the bar rear strap attachment point **191** and to the grid rear strap attachment point **173** in any suitable manner. In one embodiment (not illustrated), the first and second end portions **181** and **182** of the tension device **180** may each include a hook portion. In another embodiment, one or both of the first and second end portions **181** and **182** of the tension device **180** may include a loop portion. Various tensioning configurations also can be used, including but not limited to a come along type of arrangement (not shown).

With reference to FIGS. 9A and 9B, a plurality of acoustical blankets **200** can be placed over one face of the surface array **101** to control rear sound radiation. When acoustical blankets **200** are placed across one face of the surface array **101**, they absorb sound propagating from that face of the array, thus allowing the sound designer more control. Each of the acoustical blankets **200** is advantageously adapted for simple attachment and removal from the array **101**. In one preferred embodiment, the acoustical blankets **200** are advantageously attached to the baffle **125** using a plurality of acoustical blanket attachment portions **129**. In the illustrated embodiment shown in FIGS. 9A and 9B, the baffle **125** includes four acoustical blanket attachment portions **129**, two at each end of the baffle **125**. In other embodiments (not illustrated), the baffle **125** may include different numbers and placements of acoustical blanket attachment portions **129**. As illustrated in FIGS. 9A and 9B, in one preferred embodiment the acoustical blanket **200** includes a plurality of straps **201** designed to attach to the illustrated acoustical blanket attachment portions **129**. The acoustical blanket **200** could be attached using buttons, Velcro, snaps, laces, hooks, any combination thereof, or any of other various well-known and suitable means for attachment.

The surface loudspeaker array **101** may be suspended from the grid suspension points **172** in either the locked, non-vertically splayed position, one embodiment of which is illustrated in FIG. 1A, or in the unlocked, vertically splayed position, one embodiment of which is illustrated in FIG. 1B. FIG. 1B illustrates one embodiment of the surface

loudspeaker array **101** suspended in the unlocked, vertically splayed position. The tension device **180** is attached to the bar rear strap attachment point **191** and the grid rear strap attachment point **173**. In another embodiment (not illustrated), the surface loudspeaker array **101** could be suspended not only from the grid suspension points **172** but also from a bar suspension point on the bar **190**. In either embodiment, tightening the tension device **180** ensures that the vertically-splayable racks are vertically splayed substantially to the angle pre-set using the splay angle control slots **163** on the cam **161**.

In accordance with one aspect of the present invention, which is not necessarily found in all embodiments of the invention, the surface loudspeaker array **101** can be deployed using an extremely simple method. A surface loudspeaker array can transported in multiple pieces in wheeled cases. The wheeled cases advantageously may include a bottom wheeled portion and an upper cover portion. The first wheeled case can be rolled to an appropriate spot, and the upper cover portion can be removed, revealing a first surface loudspeaker array. A grid can be attached to the top of the first surface loudspeaker array, and the first surface loudspeaker array is then suspended from the grid suspension points. The first surface loudspeaker array is then lifted into the air, the bottom portion of the first wheeled case is removed. A second wheeled case then is rolled underneath the hanging first surface loudspeaker array. The upper cover portion of the second wheeled case is removed, revealing a second surface array. Then the top of the second surface loudspeaker array then is attached to the bottom of the first surface array using rack attachment hardware and, if vertical splaying is desired, cams. These steps may be repeated as often as necessary to create the size surface array desired. A bar may be attached to the surface array in any suitable location, and a tension device, such as a strap, may then be attached from the grid to the bar and tightened, thus forcing the surface array to splay vertically fully to the pre-set vertical splay angles. The fully assembled array then can be fully elevated to a desired location.

Similarly, in another method, sub-arrays can be configured of a number of racks. The sub-arrays can comprise any number of racks **102**. In one preferred embodiment, the sub-arrays comprise four racks **102** with each rack **102** comprising 9 PMT **150**. The sub-arrays can be packed within a wheeled case such that one sub-array is positioned in one wheeled case. The wheeled cases are commonly referred to as road cases. In one particularly

preferred embodiment, the dimensions of the road case are approximately 17 inches by 46 inches by 50-1/2 inches, which accommodates the 4 racks with 9 PMT described above. In one embodiment, the array **101** is constructed such that it forms a portion of the case, while, in another embodiment, the array **101** can be lifted from inside a separate case. The sub-arrays can be connected together in the manner set forth above. In other words, a first preassembled sub-array can be elevated and a second preassembled sub-array can be secured to the first preassembled sub-array such that the size of the array can be increased in a rapid manner.

The terms and expressions that have been employed within this specification are used as terms of description and not of limitation. There is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof. Instead, it is recognized that various modifications are possible within the scope of the invention claimed. At times modifications of or alternatives to certain features have been explicitly described. The descriptions of modifications or alternatives for some features should not be read to exclude other modifications or alternatives not so described, nor should the lack of description of modifications or alternatives for other features be read to exclude such. Accordingly, not all of the features, aspects, and/or advantages are necessarily required to practice the present invention, and therefore the scope of the present invention should not be limited by the descriptions included within this specification.